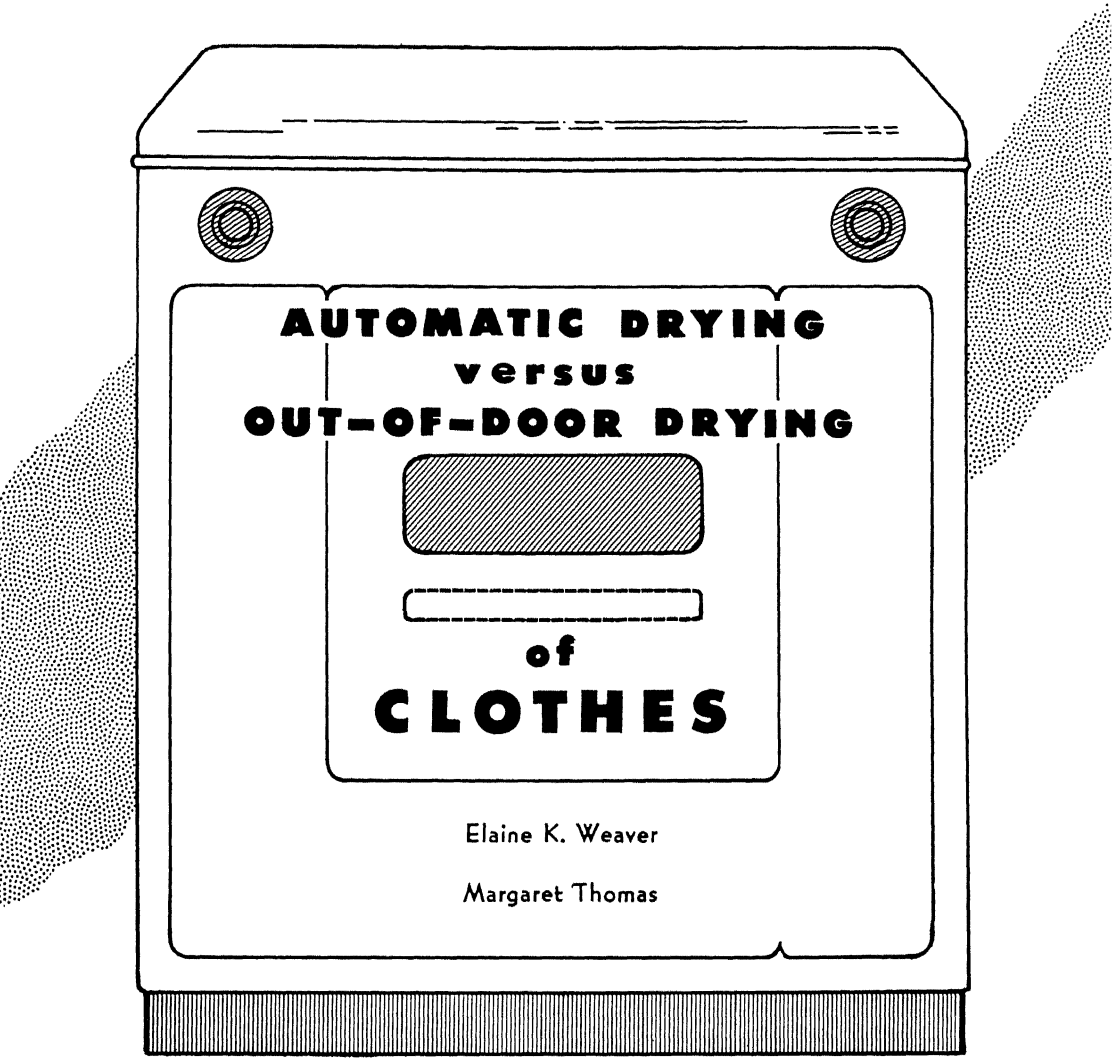
Research Bulletin 734 August 1953



AUTOMATIC DRYING versus OUT-OF-DOOR DRYING of CLOTHES

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AUTOMATIC DRYER VERSUS OUT-OF-DOOR DRYING OF CLOTHES

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SUMMARY

Automatic clothes dryers have become the fastest selling major appliance in the history of the household equipment industry. The labor saving and convenience features of the dryer have been responsible for the phenomenal acceptance. Its use not only saves time but has eliminated:

(1) Carrying and tugging of heavy baskets of wet clothes from the washing area up and down stairs and out of doors.

(2) Reaching, stretching, bending, stooping, to hang and remove clothes from lines.

Likewise, adverse weather conditions such as wind, rain, snow, or freezing temperatures need have no influence on the day or time of day for washing. Clothes are not exposed to smoke and soot, dust, tree pollen, pets, insects, or playing children. In other words, the dryer makes its own dependable washday and conditions.

Experience has taught homemakers what to anticipate when using line drying methods. Dryers, providing drastic changes in habits and practices, brought many questions from prospective buyers and occasional puzzled users. Such questions included: "Will the dryer wear clothes out faster than line drying?", "Will it fade, yellow or shrink the clothes?", "Is the money involved justified in the time saved?", "Can synthetic fibers be dried in the dryer?"

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Because of the newness of the appliance, little research information from manufacturers or other agencies was available to help answer these questions. Thus, this study was undertaken to compare out-of-door and dryer drying.

Six each of 20 household items including sheets, pillowcases, diapers, towels, shirts, T-shirts, socks, rayon blouses, nylon and rayon slips, and several pieces of yard goods typical of children's and women's dresses were selected as representative of family washings.

One each of every item was included in a test load weighing 8 pounds. Two test loads were washed 50 times in an automatic washer in a 0.3 percent low-sudsing detergent solution at 140° F. for 10 minutes, rinsed and water extracted. One load was dried out-of-doors in a semi-shaded area; the other was dried in an electrically heated dryer for 44 minutes at high heat. Time was determined in pretesting.

Three other test loads were soaked 50 times without mechanical action in an automatic washer in 140° F. water for 5 minutes. One load was line dried out-of-doors; the second was dried in the electric dryer at high heat; the third, in a gas dryer also at high heat.

One test load was left unwashed for comparison of final results. Standardized tests were used for measuring whiteness and color retention, strength and weight loss, wear, shrinkage and distortion.

Strength, Wear and Weight Loss

Lint, a natural result of wear in cotton and linen fibers, found in lint traps and deposited in areas near dryers concerned new users. Surely, they thought, the dryer must be "hard" on clothes. In line drying the lint blows away unrecognized in the air.

Tests showed that washed items such as sheets, broadcloth shirts, pillowcases, rayon and nylon slips, linen towels, and cotton dress goods lost less tensile strength when dried in the dryer, while items with considerable nap, such as terry cloth towels and diapers lost slightly more than when dried on the line. Washed items dried by both methods lost more strength than did those that were merely soaked.

Whiteness Retention

Sunshine, traditionally thought to be a necessary element for whitening clothes, has been the most frequent argument used by skeptics against a dryer.

White items dried in the dryer 50 times were almost as white or whiter than when new in practically all cases. When dried out-of-doors all items except pillowcases, diapers, and nylon slips were whiter than new. The fluorescent dyes in the detergent which react in sunshine and not in the dryer may have contributed to this difference.

Differences between dryer and line drying were so slight that they could hardly be distinguished by the eye and were only slightly noticeable on the reflectance meter.

Unless clothes are well washed neither line or dryer drying will perform miracles. Curd formed when soap is used in hard water and retained by white clothes may oxidize in the sun causing yellowing of white items. This problem is eliminated when synthetic detergents are used. Poor rinsing, when either type of detergent is used, may result in yellowing of white clothes by heat from dryers.

Color Retention

That the dryer excelled in color retention was well illustrated in this study. Although colored clothes were dried in a partially shaded area during the spring months all colored items faded, particularly those containing red dyes. In the dryers, all colors even those washed 50 times in hot detergent water remained as deep and clear as new with one exception. Unstable blue dyes turned green in the gas heated dryer.

Shrinkage (Dimensional Change)

Shrinkage was the only factor where line drying might be considered superior to dryer drying. Materials which inherently shrink such as cotton knits, towels, diapers and loosely woven fabrics shrank somewhat more in dryers. If cotton knits were removed while slightly damp and were stretched and blocked into shape the results were similar to line drying.

Although shrinkage was slightly higher in garments dryer dried, yet items dried by this method were softer, generally less wrinkled, and in the case of diapers, more absorbent than were the line dried ones. To offset possible shrinkage cotton knits such as T-shirts can be as cheaply purchased in a size or two larger and, if necessary, be washed before wearing. In a previous study it was shown that all-wool blankets were successfully dried in the dryers.

Time Saved

The time saving factor was not specifically considered in this study. In a few timing processes it was found that about one-sixth the amount of time was required to load the clothes into the dryer and fold them when dry as when hanging and folding clothes from the line. Likewise, the steps were reduced from 625 for each 8 pound line dried load to practically none in the use of the dryer. Only a few bends were necessary to load and unload the dryer thus eliminating the carrying, lifting, stooping, stretching necessary for hanging and removing clothes from the line.

Weather Conditions

Dryer drying of 150 test loads was completed within a few days because weather was no factor and work could be done at any time. A period of 151 days was required to complete the 100 test loads in the line drying part of the study since only one day in four was suitable for out-of-door drying. On 92 days there was snow, rain, or sleet with strong winds on 67 days. Pollen from trees stained numerous items.

Cost of Operation

Frequent inquiries concerned the choice between gas or electric models and their cost of operation. The choice may depend upon availability of gas service and heavy duty (220 V) electricity in the home, (115 V dryers are available, but drying time is too long to be practical) and the prevailing rates.

The initial cost of electrically heated models is generally from $25.00 to $45.00 less than the gas heated models of the same brand but the cost of operation is generally higher.

An average of 2.7 K.W.H. of current was used to dry each 8 pound load. Considering 16 loads a month, as average, at 2.5¢ per K.W.H. the cost would be $1.08 per month. Gas consumption was 9.6 cubic feet per load. At Columbus, Ohio, gas rates of 1¢ per 20 cubic feet the cost of gas would be approximately 7.7¢ per month. The cost of electricity for the operation of the motor for the gas heated model would approximate another 7¢ or a total cost of about 15¢ per month.

No attempt was made to compare the performance of different brands of dryers on the market.

From the experience gained in this and previous studies it is believed that no other major household appliance can contribute more to time and enegry management in the home. If for financial reasons, it was necessary to choose between an automatic washer and no dryer or a wringer washer and a dryer, our choice would be the latter combination.

Besides the favorable features already cited the use of a dryer can reduce the number of clothing items needed particularly for infants and growing children since quick drying is no problem.

As experienced by several Franklin County, Ohio, homemakers who participated in a previous study, the use of fabrics flattered by the dryer reduced ironing to ¼ their previous ironing time. Such fabrics and items as chenille bedspreads and draperies, terry cloth robes, rough fabric tablecloths and place mats, corduroys, twills, seersuckers, velveteens and others if properly handled are ready for wear directly from the dryer.

PURPOSE OF RESEARCH

Drying clothes on laundry day has always been a major problem for the homemaker. Adverse weather conditions such as rain, snow, sleet, wind and high humidity have contributed to the problem. In addition, local conditions such as dust, smoke, soot, pollen from trees, pets, and insects add to the difficulties. Energy requirements for hanging clothes out-of-doors have been another factor. Frequently, lines are some distance from the laundering area, requiring many steps to carry heavy baskets up basement stairs, out to the drying line, to hang, and later, to return to lines, to remove clothes, and to carry the baskets back into the house. In this process women doubtlessly do more bending, stooping, lifting, and reaching than in any other household task.

Women have traditionally believed that clothes needed to be dried in the sun and air because of whitening, fluffing, and "good smell" effects. As long as the weather was acceptable, most women have preferred drying clothes out-of-doors. In adverse weather conditions laundering has been postponed or clothes have necessarily been dried on racks and lines in kitchens, bathrooms, basements, attics or any available space. Indoor drying has been a frequent source of annoyance because of lack of space and the moisture dissipated throughout the house.

Automatic tumble type clothes dryers first appeared in 1946. Their introduction was an attempt on the part of the manufacturers to eliminate as many of the clothes drying problems as possible. Public acceptance of this appliance has been phenomenal. Within six years they are to be found in nearly two million homes (Figure 1).

The purchase of this new appliance has meant a large and long time financial investment for most families. Furthermore, its use has meant a drastic change in habits and traditional practices used when line drying.

As a result, during the past five years, a steady stream of inquiries from prospective buyers and new users has come to the investigators of the Ohio Agricultural Experiment Station and the School of Home Economics asking such questions as: "Should I buy a dryer?", "Which brand is best?", "What is the cost of operation?", and "Should I buy a gas or an electric model?"

Still other questions had to do with performance. Among these were "Will the dryer fade, yellow, or wear clothes out faster than line drying?", "Is there more shrinkage?", and "Can all kinds of fabrics be dried in the dryer?"

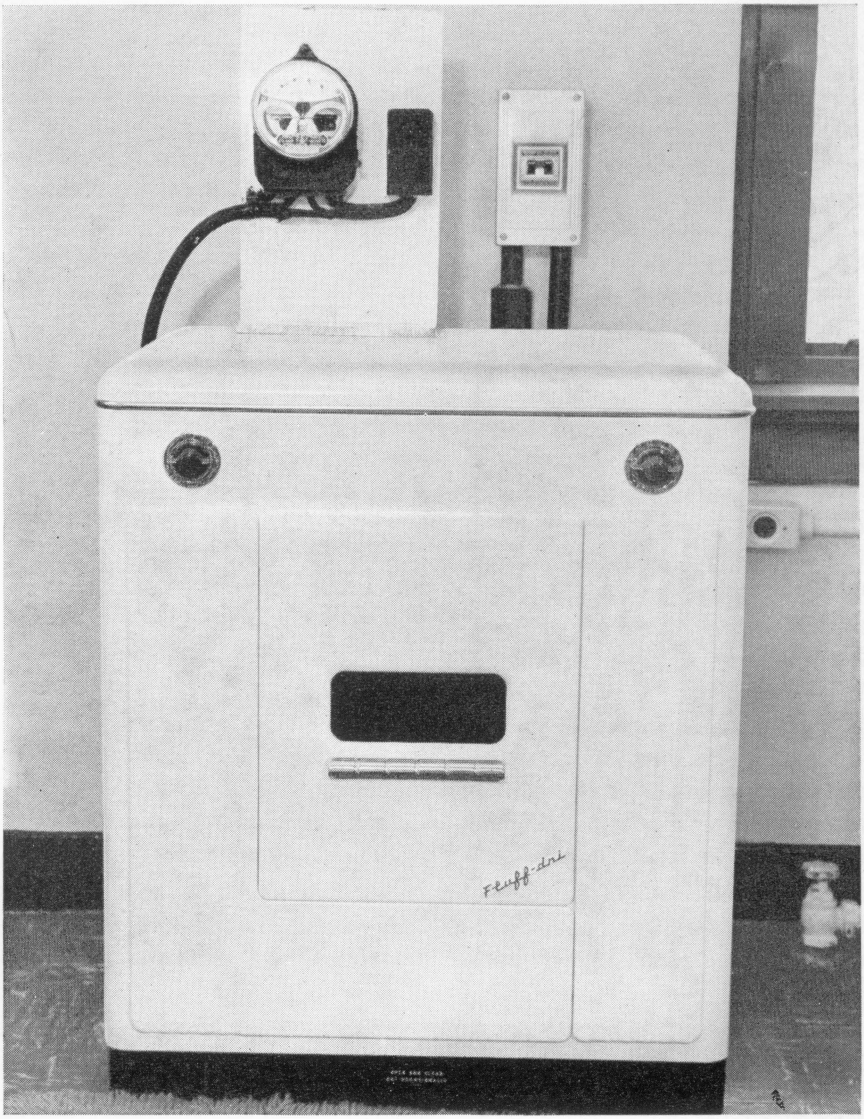

Fig. 1.—The dryer, a simply constructed appliance, consists of a motor driven drum within an outer steel cabinet. Wet clothes, tumbled as the drum rotates, are dried by means of air currents heated by a thermostatically controlled electric element or gas flame. Moisture, heat, and lint are expelled through an exhaust duct.

Because of the newness of the appliance even the manufacturers could not answer certain of these questions. No research information from other sources was available.

In order to adequately answer as many as possible of the requests for information a research study was carried on over a period of a year, 1950-51. Previous to this time some 20 tons of family washings done in a study of automatic washers had been satisfactorily dried in dryers but no comparative results with line drying had been made.[3]

The main purpose of this present study was to investigate factors such as wear, whiteness and color retention, shrinkage, distortion, cost of operation of the dryers, and time saving features, and make comparisons of the results obtained in out-of-door drying with those of dryer drying.

BACKGROUND MATERIAL

When using the dryer in previous studies, considerable variations in drying times were noted. The amount of water retained by an 8 pound load of clothes (dry weight) following extraction in different washers or by wringers varied. Thus it was necessary to determine the amounts of water retained and the relative drying times required.

(1) For this determination an 8 pound load of typical household items was soaked for 5 minutes in water, 140° F., in each of 8 automatic washers and one wringer model. Following the soak period the controls of the washer were advanced for the final extraction period or clothes were run through the wringer. Each time the load was carefully reweighed to determine water retention.

Following the weighing the load was placed in a gas heated dryer which was allowed to operate for 30 minutes after which time the clothes were removed and re-weighed at intervals until the load had returned to its original weight and the time was recorded. This process was repeated for each washer at least three times to carefully determine the exact drying time needed.

As can be noted in Table 1, the water retained in the 8 pound load varied from 4 pounds, 1 oz. (approx. 2 qts.) to 10 pounds, 5 oz. (approx. 1 gal. 1¼ qts.) and drying times varied from 27 to 69 minutes, respectively when dried in the same dryer.

(2) To ascertain if there was appreciable difference in drying time between the gas and electrically heated models of the same brand, similar tests were repeated for the electrically heated dryer. Specifications for these two models are given on page 12.

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[3]Weaver, Elaine Knowles "A Study of Three Types of Automatic Washers" Agricultural Experiment Station Bulletin 715, Wooster, Ohio, 1951.

The electrically heated model was placed on a carefully calibrated platform scale.[4] (See Figure 2). The test load was placed in the dryer and the scale was set at dryer weight plus 8 pounds (dry weight of the clothes). When the scale balanced the drying was complete and the time was recorded.

TABLE 1.—Water Retained in an Eight Pound Load of Clothes after Extraction in Various Washers, and Approximate Drying Time in a Gas-heated Dryer at High Heat

Washer	Spinning speed	Extraction time	Average water retained		Average drying time	Average gas consumption
	R.P.M.*	Min.	Lb.	Oz.	Min.	Cu. ft.
1	550	7	5	10	39	9 2
2	575	5	8	6	55	12 9
3	Vacuum	4	10	5	69	16 2
4	525	4	7	7	50	11 8
5	1140	3	4	1	27	6 3
6	650	6	5	5	35	8 2
7	500	6	9	2	61	14 3
8	618	4	5	15	40	9 4
9	Wringer	—	8	12	58	13 6

*Revolutions per minute

Only loads from a washer, chosen for this study because of average water retention, (5 lbs. 10 oz.) were checked in the electric dryer during this preliminary testing period. Drying time in this model was 44 minutes as compared to 39 minutes in the gas heated model.

CURRENT STUDY

EQUIPMENT AND MATERIALS USED FOR STUDY

In the survey of literature, no information could be found on methods of study or test procedures for automatic clothes dryers. At the beginning of this study only five companies were manufacturing dryers. Two of these companies also made models for various other well-known manufacturers who sold them under their own brand names.

[4]Permanent installation with rigid tubing made it impossible to check drying time of the gas heated dryer by this method.

Previous use of each of the different manufacturers' dryers seemed to indicate similar results. For this reason the gas heated and electrically heated models made by only one manufacturer were used in this study.

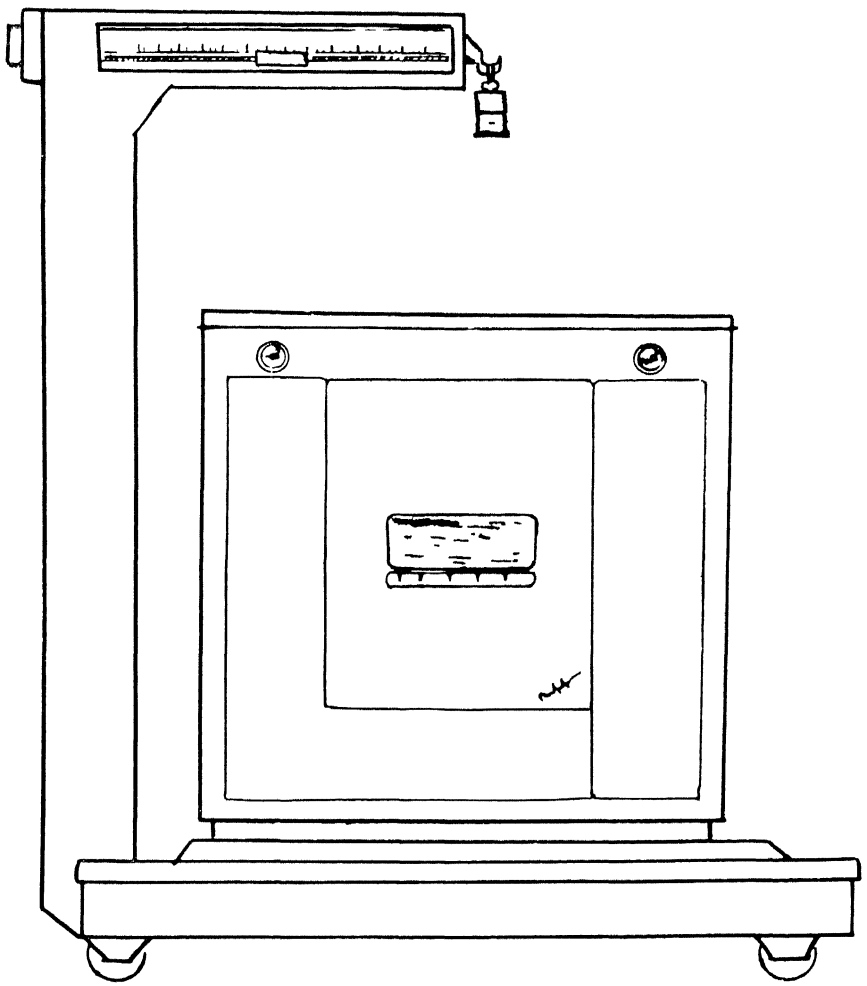

Fig. 2.—The calibrated scale on which the dryer was mounted to determine the time at which a test load was returned to its original dry weight.

DRYERS USED FOR STUDY

The dryer, a simply constructed appliance, consisted of a motor driven drum within an outer steel cabinet. Wet clothes, tumbled as the drum rotated, were dried by means of air currents heated by a thermostatically controlled electric element or gas flame. Moisture, heat, and lint were expelled through an exhaust duct (Figures 1 and 2).

Features and specifications included:

1. Source of heat: Electric 230V, 4400 watt chrome nickle alloy element; or gas, a standard multiple post design burner capable of delivering 17,000 B.T.U.s per hour.
2. Capacity: 9 pounds of dry clothes.
3. Drum rotated 50 R.P.M.
4. Moisture removal—11-12 lb. per hr.
5. Germicidal lamp.
6. Drying time controlled by a 60-minute timing dial.
7. Adjustable heat with maximum temperatures reached at:

Low heat	145° F.	(± 10°)
Medium heat	165° F.	(± 10°)
High heat	190° F.	(± 10°)

8. Heater and drum shut off when door was opened.
9. Contained a positive control (fuse link) in case of overheating.
10. 1/6 Horsepower motor.
11. Automatic overload protection.
12. Ground wire for motor connected.
13. Cabinet size: Width 31 inches, Height 39 inches, Depth 26 1/6 inches.

The two dryers were installed in the laundry research laboratory located at the School of Home Economics, The Ohio State University, Columbus, Ohio. Both dryers were attached to meters so that their consumption of gas and electrical energy could be determined during the drying periods.

DRYING YARD AND ACCESSORIES

The yard used for the out-of-door drying was that of a University staff member located approximately 100 feet from the laundry research laboratory where tests were conducted. Some shade was provided by surrounding trees but there was much direct sunlight between noon and

4:00 p. m. on bright days. Clothes were wheeled to the yard in a laundry cart. Hanging was done with old fashioned wooden clothes pins. The yard and conditions were considered typical of those found at many rural Ohio homes. In case of rain while clothes were drying they were brought to the laboratory and drying was completed on indoor racks.

WASHER USED FOR STUDY

Since clothes were washed or merely soaked before drying in the study some method of washing and water extraction was necessary. The particular automatic washer chosen was one that gave the average amount of water extraction of all automatics and/or a good wringer (Fig. 3). Its features included: a porcelain enamel top loading cylinder; an agitator with a metal base and flexible rubber fins; centric agitation operating at 300 pulsations per minute; a washing cycle of 38 minutes; flexible dial control; capacity of 30 gallons of water per load for wash, one deep and overflow rinse.

MATERIALS AND METHODS OF TREATMENT USED FOR STUDY

To duplicate the items most frequently found in the weekly wash basket in the previous study of automatic washers[5] six each of 20 clothing and household items of good quality were selected. All of a kind were chosen from the same lot and box when purchased. Yard goods were purchased in lengths and cut into yard length pieces. Materials used were:

1. Men's white broadcloth shirts, size 17-35 (Sanforized).
2. Men's white knit T-shirts, size 42.
3. Men's white knit shorts, size 36.
4. Men's white cotton socks, nylon reinforced toes, size 9.
5. Men's linenized socks, size 9.
6. Children's knit sleepers, size 4.
7. Children's cotton flannelette pajamas, size 8.
8. Gauze diapers, (21 × 40 inches), cotton.
9. Birdseye diapers, (27 × 27 inches), cotton.
10. Women's woven white nylon slips, size 16.
11. Women's woven white rayon slips, size 16.

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[5]Ibid 1.

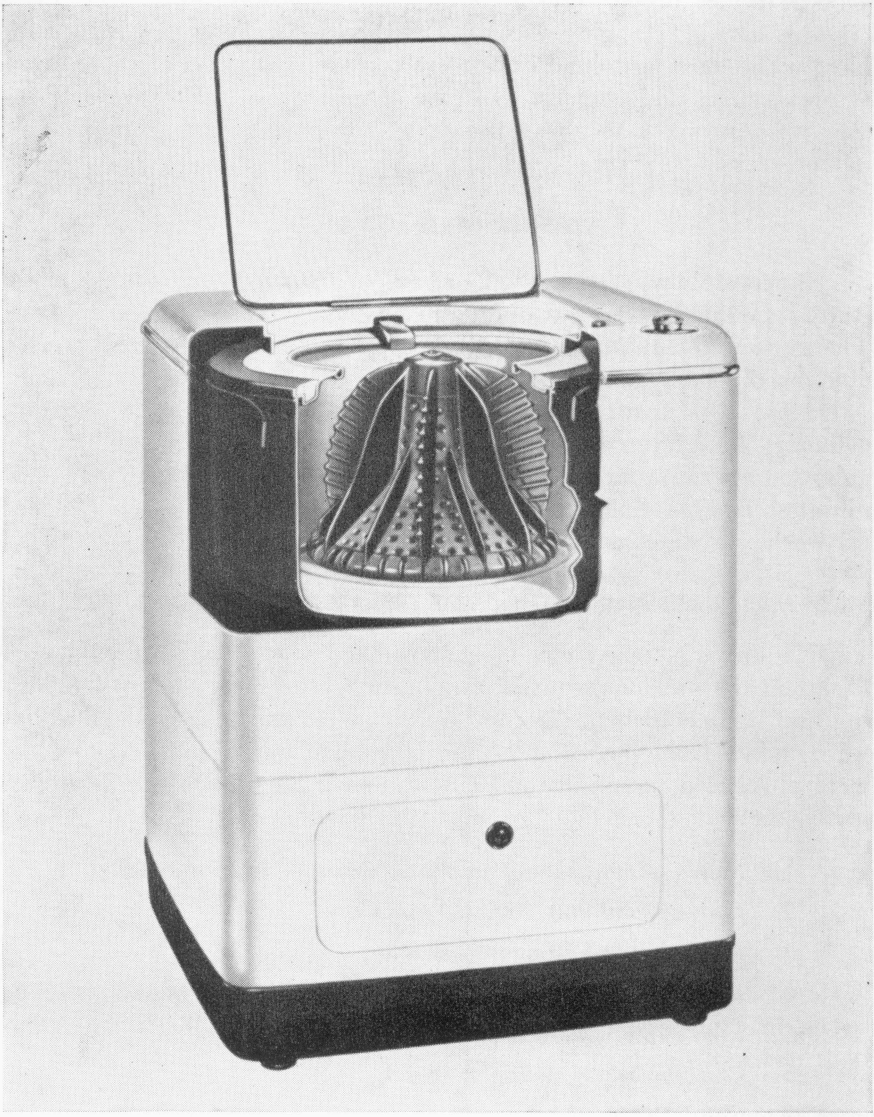

Fig. 3.—A cut-a-way illustration of the washer used for the tests in which test loads were washed before being dried out-of-doors and in the electrically heated dryer.

12. Women's acetate rayon blouses, size 36.
13. Red print cotton seersucker.
14. Blue print cotton broadcloth.
15. Striped multi-colored cotton pique.
16. Crib sheets, percale (45 × 72 inches).
17. Pillowcases, combed percale (42 × 38½ inches).
18. Terry cloth bath towels, rose and blue; color guaranteed fast.
19. Luncheon napkins, rayon and cotton blend, white with green border.
20. Linen tea towels, natural color.

Six different sets of each of the 20 items plus additional stuffer items (towels and pillowcases not used for testing) were used to make an eight pound test load, (Fig. 4). One set of items was held without treatment as a control. Five identical loads were treated 50 times in the following manner:

Test load 1. Washed for 10 minutes in water, 140° F. with a 0.3 percent detergency (low-sudsing synthetic detergent was used), rinsed and water extracted. The clothes were dried out-of-doors until they "felt" dry.

Test load 2. Soaked for 5 minutes in water 140° F. without detergent and water extracted. Drying of this load was done out-of-doors in the same manner as in test 1.

Test load 3. Washed in the same manner as test load 1 but dried in the electrically heated dryer for 44 minutes at high heat. (Time predetermined by preliminary testing).

Test load 4. Soaked and water extracted as in test 2 but dried in the electrically heated dryer for 44 minutes at high heat.

Test load 5. Soaked and water extracted as in test 2 but dried in the gas-heated dryer for 39 minutes.

Observations were made on (1) wear and weight loss, (2) whiteness and color retention, (3) shrinkage and distortion of materials, (4) drying time, and (5) cost of operation. The details of preparation of materials, testing methods, and observations made follows.

Since the features of both models of dryers were the same except for the sources of heat, gas and electricity, it was thought unnecessary to duplicate both washed and soaked loads for drying in both dryers. For this reason, as it can be noted, only the soaked load was gas dryer dried.

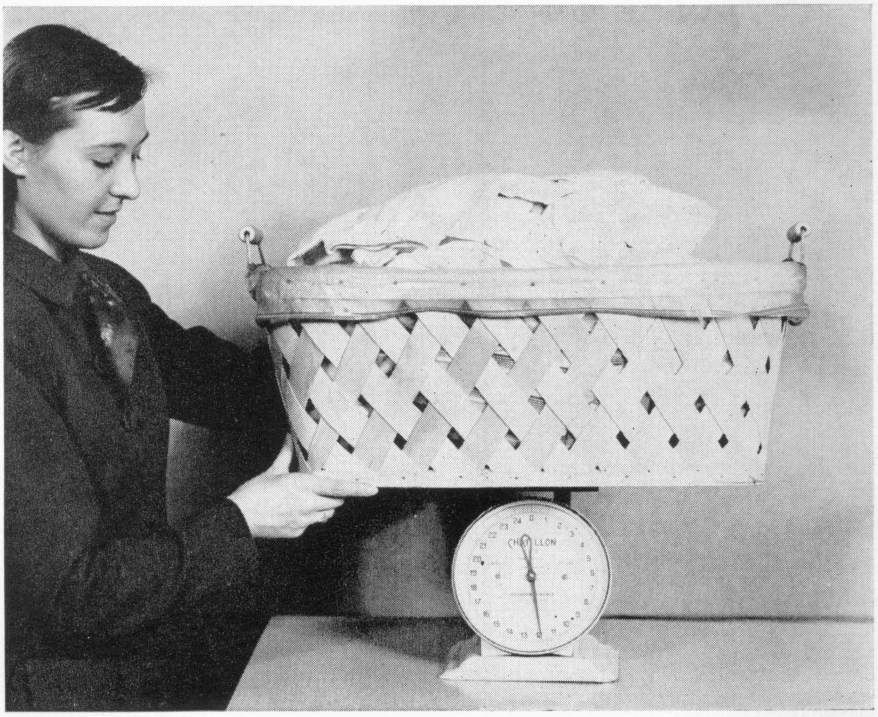

Fig. 4.—An eight-pound load which included all test items plus stuffer items was carefully weighed.

STRENGTH AND WEIGHT LOSS TESTS

Purpose and Procedure

"Won't clothes wear out faster in the dryer than when line dried?" This frequently asked question was prompted by the presence of lint in lint traps or in drying rooms when a dryer was in use; also by the fact that clothes were tumbling in the presence of heat. Not being able to see the lint from clothes as it blows in the air in out-of-door drying, it is probable that women have not realized that the same thing was happening.

Wear on fabrics by the various treatments was measured by tensile strength tests. The method used to determine the strength loss in the study was a standard method (raveled-strip) set up by the Bureau of Standards.[6]

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[6]Textiles—Testing and Reporting. National Bureau of Standards, United States Government Printing Office (1944), p. 4.

Test specimens 6 inches long and 1¼ inches wide were cut from each article, 5 in the warp and 5 in the filling directions, from new and from fabrics which had been treated 50 times by the various washing and drying methods. Locations were staggered in the same piece to avoid using the same warp and filling threads. Each specimen was raveled to 1 inch in width by taking approximately the same number of yarns from each side.

A motor-driven pendulum machine, the Scott Tester, was used for measuring the strength of the specimen (Fig. 5). The jaws through which the load was applied moved at a uniform rate of 12 ± ½ inches per minute. Specimens were placed in the jaws with the long dimension parallel to, and the short dimension perpendicular to, the direction of the application of the load. At least four hours prior to testing, all specimens were placed in the conditioning room in which the tester was located, with a relative humidity of 65 percent and temperature of 70° F.

Tensile strength was calculated and expressed in pounds (force) pressure required to break one inch square of the test fabric. Percentages of loss or gain in strength were calculated by use of the formula:

$$\frac{\text{Tensile Strength of Test Fabric—Tensile Strength (new)}}{\text{Tensile Strength (new)}} \times 100 = \text{Percentage of Strength loss or gain}$$

Results of Tests

Variability in the results of tensile strength tests made it difficult to draw definite conclusions. No doubt a larger number of test swatches would have provided more reliable data. These tests were made on only one of each garment which limited the number of samples for testing.

In broadcloth shirts, sheets, rayon and nylon slips, seersucker, cotton prints, pique, and linen towels which had been either washed or merely soaked there was less loss of tensile strength in the warp when dried in the dryer than on the line, whereas items with more nap, or more loosely woven, lost slightly less strength when line dried. When washed, six of the line dried and all dryer dried items except gauze diapers gained in tensile strength in the filling direction. When merely soaked, 10 of the 15 items in the electric dryer and 7 in the gas dryer did so.

No direct relationship between tensile strength changes and shrinkage could be established even though shrinkage was higher in dryer

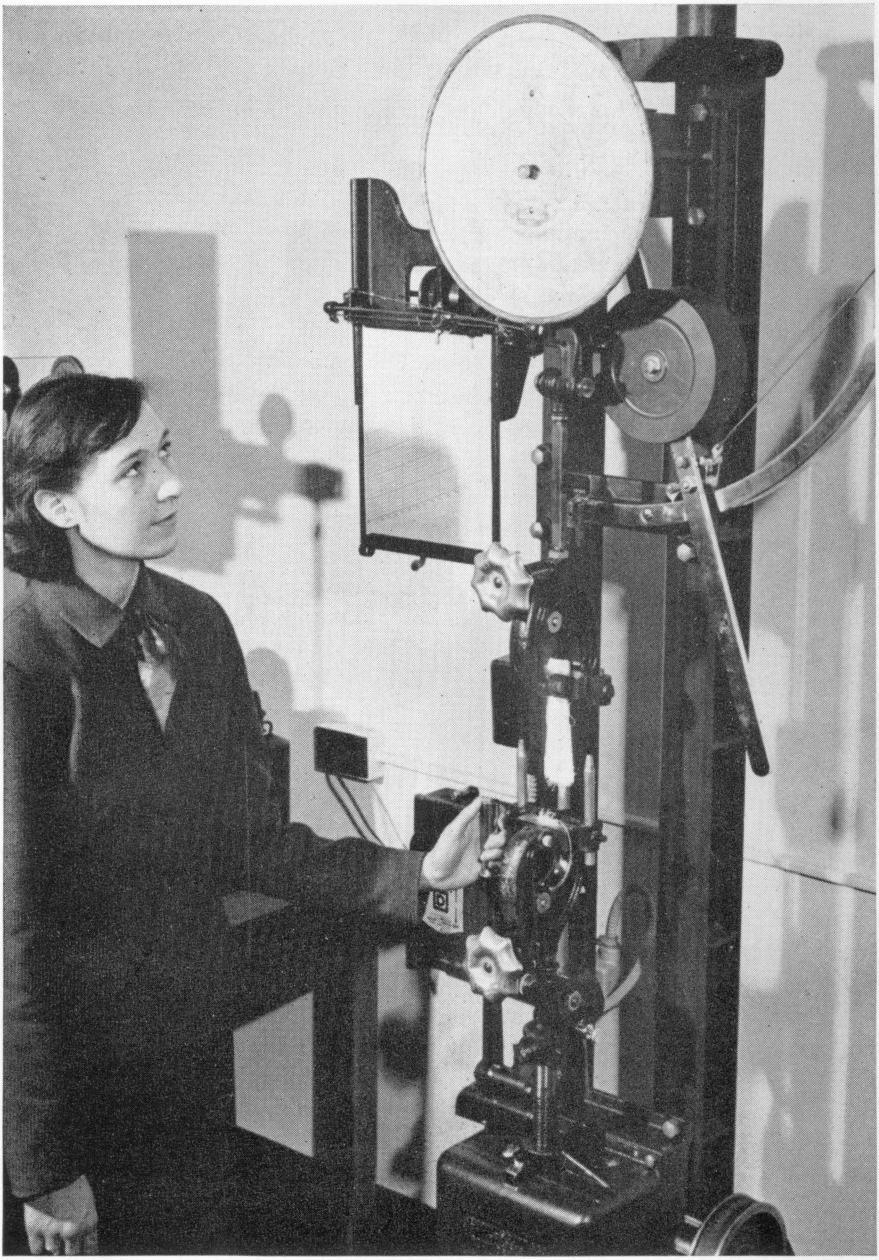

Fig. 5.—The Scott Tester used to determine tensile strength loss of the test materials.

TABLE 2.—The Percentage of Tensile Strength Change in Articles

Article	Washed and Dried Fifty Times				Soaked and Dried Fifty Times					
	Warp		Filling		Warp			Filling		
	Out-of-door	Electric dryer	Out-of-door	Electric dryer	Out-of-door	Electric dryer	Gas dryer	Out-of-door	Electric dryer	Gas dryer
	Percent*				Percent*					
White shirt	8 9	6 8	4 1	+11 4	6 4	2 5	3 0	8 2	1 0	11 2
Sheet	8 2	0 0	1 1	+ 2 2	3 6	5	2 1	+ 5 5	+ 8 3	+ 1 1
Pillowcase	+ 5	+ 1 0	2 7	+10 3	6 2	+ 5 7	1 0	9 2	+17 8	+ 4 3
Gauze diaper	18 7	23 7	0 0	3 7	21 0	24 7	7 8	4 6	8 3	21 3
Birdseye diaper	1 4	14 5	+19 7	+ 4 6	+ 9 4	1 5	+ 6 5	7 1	+ 5 0	+11 8
Blue Towel	13 0	15 1	+ 6 7	+16 9	2 5	15 8	7	+26 2	7 2	+21 0
Rose Towel	2 6	6 1	+10 7	+ 1 1	+14 3	3 9	+15 7	+30 5	+ 1 1	+16 6
Flannel pajama	+11 6	4 2	+51 9	+38 9	+11 6	0 0	+10 5	+22 2	+33 3	11 1
Rayon Napkin	7	15 5	4	+ 8 0	12 6	11 9	16 4	3 7	+12 8	+ 6 4
Rayon slip	43 6	21 3	+ 6 6	+11 5	21 3	20 2	16 1	31 1	+15 6	8 2
Nylon slip	13 9	+ 2 5	5 0	+13 9	24 9	+ 4 3	3 6	+18 1	+ 1 0	+ 6 9
Red seersucker	28 3	+17 4	26 5	+ 2 0	17 4	+26 1	+15 2	30 6	6 1	16 3
Cotton print	25 6	+ 7 7	+ 4 4	+31 9	26 7	+ 2 6	12 8	12 1	+20 9	4 4
Linen towel	64 3	16 0	3 1	+12 1	32 2	15 0	21 1	+16 0	3 9	10 5
Striped pique	14 0	4 3	42 1	+13 2	14 0	+ 4 3	11 8	38 8	+13 8	0 0

*A + sign indicates an increase in tensile strength

dried items than in those line dried (See page 19) (Table 2). Shrinkage in fabrics brings the yarns more tightly together and up to a certain point may tend to increase the tensile strength above that of the new fabric.

Because of the variation in the tensile strength tests it cannot be said that one method of drying was superior to the other, but, in general, the dryer results seemed more favorable than those of line dried.

WEIGHT LOSS

Standardized methods for measuring weight loss in fabrics were not considered practical for this study since they necessitated cutting specimens from articles to be tested.

Before the washing and/or soaking and drying tests were begun, each article was placed in the control room with 65 percent humidity and at 70° F. for 24 hours to gain moisture equilibrium of the fibers, and then weighed on gram scales. (Fig. 6). Following the 25th and 50th drying treatment the same procedure was followed. For calculations of weight loss the following formula was used.

$$\frac{\text{Original Weight—Weight after testing}}{\text{Original Weight}} \times 100 = \text{Percentage of Weight Loss}$$

Results

In general, articles washed and dried out-of-doors lost a slightly higher percent of weight than did those dried in the electrically heated dryer. Although slight, there was an increase in weight loss as the tests progressed. When clothes were soaked the difference between results in weight loss by either method was so small that there was no appreciable difference to be noted. No explanation could be given for items showing slight increases in weight (Table 3).

As previously mentioned, the presence of lint in the dryer trap and in the room following the drying of clothes was a factor that led to the question of excessive wear on the clothes. Since the weight loss in items dried on the line appeared to be slightly higher than that in the dryer it seems indicative that lint was also blown from the clothes and went unnoticed in the air.

The electric dryer was carefully cleaned after each of the 50 drying periods and the lint that had collected in the trap was saved. In Figure 7 it can be noted that the lint collected from the dryer when the clothes

had been washed before drying was twice in weight (8 grams) to that collected when the clothes had merely soaked before drying (4 grams). It would seem that lint was also created by the agitation in washing. It is recognized that a certain amount of the fine lint not caught in the trap was dissipated in the air and deposited about the room.

Figure 8 shows the effect of both methods of drying on acetate rayon blouses. It is not probable that blouses of this type would ordinarily be subjected to fifty washings and dryings by any method. It is interesting to note, however, that when blouses were machine washed and dried either out-of-doors or in the dryer the seams were so badly frayed that the blouses had practically fallen-to-pieces. When the blouses were merely soaked and dried by either method very little fraying resulted. The blouse that was dryer dried (D) was in the dryer at high heat for 33⅓ hours. In the case of these blouses it is obvious that washing action had far greater wear effects than did the drying action.

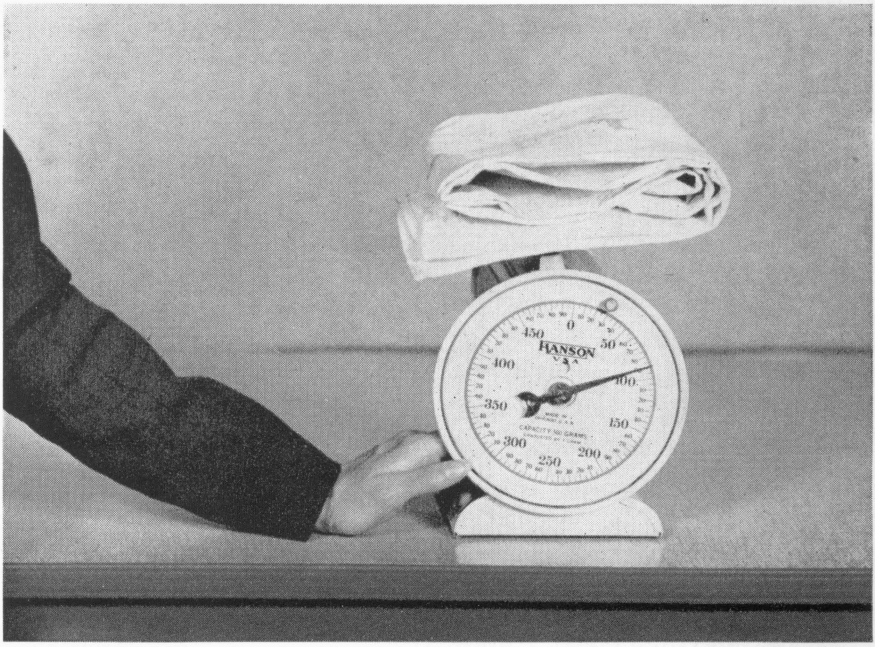

Fig. 6.—Gram scales were used to determine the weight of articles before and after fifty washing and drying tests.

Purpose and Procedure

"Won't white clothes yellow and won't colored clothes fade or dull in the dryer?"—The belief that sunshine is an important ingredient in keeping clothes white is traditional. In order to determine the answer further tests were made.

In the first place the whiteness of each item had to be measured when it was new. A photo-electric reflection meter designed for measuring the diffuse reflection of surfaces was used. (Fig. 9).

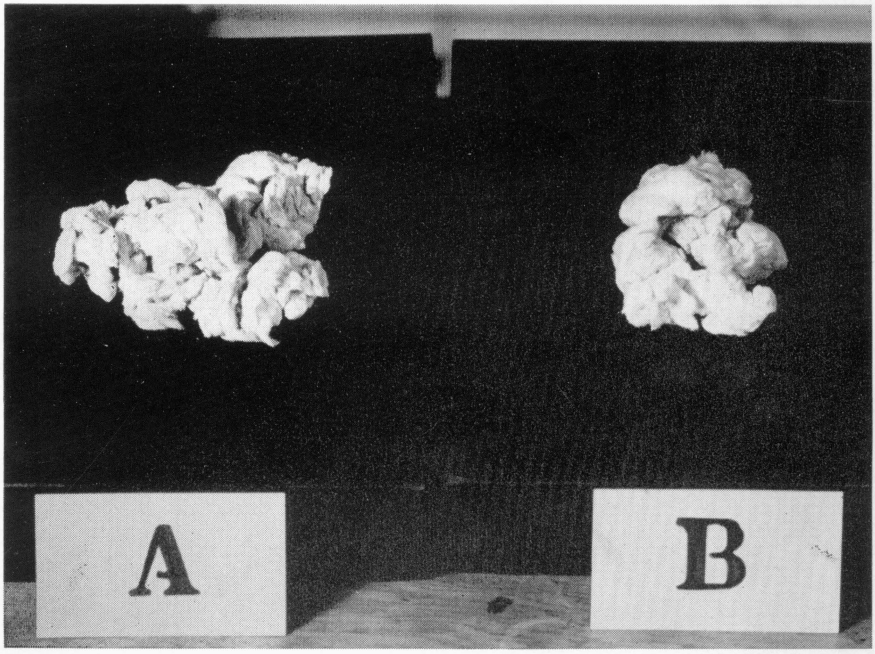

Fig. 7.—Lint collected from the electrically heated dryer during 50 tests.

A. Washed load, 8 grams
B. Soaked load, 4 grams

The reflection meter consisted of 3 units: (a) the instrument proper containing the controls, (b) a search unit which comprised the light source and (c) the photocell. An enameled plaque with a luminous apparent reflectance of approximately 75 percent (relative to magnesium oxide as 100 percent) was used as a working standard for setting the galvanometer prior to taking the measurements.

TABLE 3.—The Percentage of Weight Loss in Articles Washed and/or Soaked and Dried Twenty-five and Fifty Times

Article	Washed and Dried				Soaked and Dried					
	Out-of-doors		Electric dryer		Out-of-doors		Electric dryer		Gas dryer	
	Number of times dried				Number of times dried					
	25	50	25	50	25	50	25	50	25	50
	Percent*				Percent*					
Knit T-shirt	.8	1.2	1.3	1.3	+ .9	+1.3	1.7	1.7	.8	0.0
Child's sleeper										
Top	2.7	3.7	+1.8	1 1	1 7	2.4	6.0	6 0	1 4	.3
Bottom	2.6	3.6	.3	2 3	1.6	2 3	5.4	5 4	2 4	1.4
Man's shirt	1.4	2.7	3 5	3 5	1 0	1.8	1 8	1 8	.4	+ .6
Sheet	1.7	3.5	1 4	5	1 2	1 7	.8	8	1.4	.3
Pillowcase	.4	1.8	4	.4	0 0	1 1	1.5	1.9	.8	+ .4
Rayon blouse	6.1	6.5	3 9	6 9	.4	1.3	3 4	3 8	2.6	.4
Gauze diaper	.8	2.5	1.7	2.5	0 0	0 0	0 0	.8	0 0	+ .2
Birdseye diaper	.2	.4	0.0	0.0	+ .8	0.0	0.0	8	0 0	+ .8
Knit shorts	2.6	2.6	.7	.7	6 5	.7	2 7	2 7	7	0.0
Blue towel	2.3	3.4	.4	0.0	1.3	1.6	.2	.4	2	1.7
Rose towel	2.3	4.2	1 1	.9	1.8	1.8	1.0	.8	+2.0	+1.3
Linenized sock	.6	.6	+6.9	+ 3.4	.3	.6	+6 9	+3.4	0 0	+3 0
Cotton sock	10.9	10.9	1.9	5 8	3.5	5.3	1.9	1.9	3 8	1.9
Flannel pajama										
Top	4.8	6.4	2 7	3 8	1 5	3.0	3.6	4.6	3 1	3.1
Bottom	5.3	6.6	1 6	3.6	1.5	4.0	4.1	4.6	3 0	3.0
Luncheon napkin	4.8	4.8	0.0	2.4	0.0	0.0	+1.2	0.0	1.3	1.3
Rayon slip	1.5	5.5	1.8	2.9	2.6	+ .4	1.9	2 2	1 8	.4
Nylon slip	3.8	.5	0 0	5	+ .5	.5	.5	2.2	1.1	.5
Cotton seersucker	5.6	5.6	1.7	11.2	0.0	1.6	.8	1 6	.8	0 0
Cotton broadcloth	8.3	9.0	4.0	6.0	.5	2.1	1 5	2.5	.5	.5
Cotton pique	3.9	4.8	2.2	2 7	.4	1.8	3 5	3 9	2.2	2.2

*A + sign indicates an increase in weight

Reflectance of each of the tested articles was measured 12 times and the average calculated. Following the 25th and 50th dryings the reflectance was measured in the same way. The color or whiteness retention was calculated and expressed as a percentage of the average reflectance of the article when new.

$$\frac{\text{Original Reflectance}}{\text{Reflectance after Treatment}} \times 100 = \text{Color or Whiteness Retention in Percent}$$

Results

Whiteness Retention: After 50 tests, articles washed and dried out-of-doors were generally whiter than when new. Exceptions were the pillowcases, birdseye diapers, and nylon slips (Table 4).

Several items increased in whiteness after 25 washings and dryings in the electric dryer but declined slightly after the 50th washing. Sheets, linen towels, napkins, and socks were still slightly whiter than when new, after 50 tests.

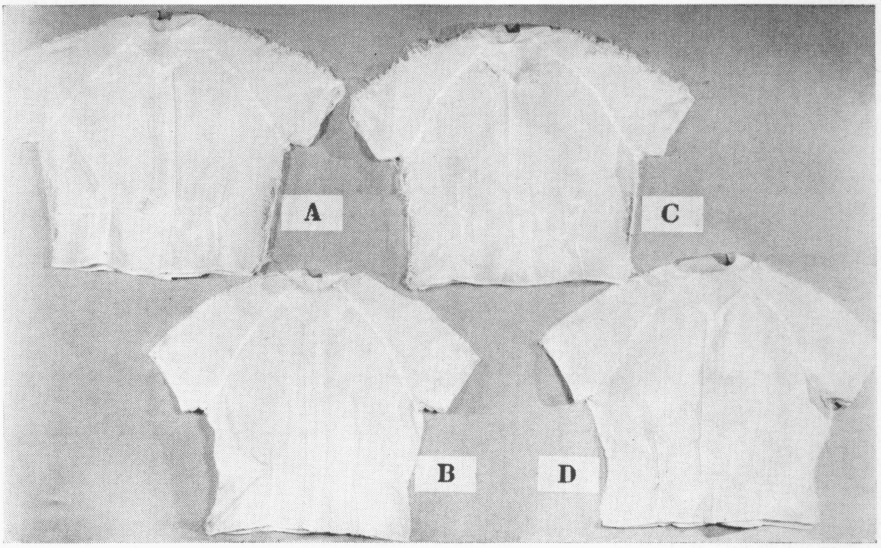

Fig. 8.—Rayon blouses after 50 tests.

A. Washed and dried out-of-doors
B. Soaked and dried out-of-doors
C. Washed and dried in electrically heated dryer
D. Soaked and dried in electrically heated dryer

TABLE 4.—The Percentage of Whiteness Retained by Articles after Washing or Soaking and Drying Fifty Times Out-of-doors or in Clothes Dryers

Article	Washed and Dried		Soaked and Dried		
	Out-of-doors	Electric dryer	Out-of-doors	Electric dryer	Gas dryer
			Percent*		
Sheet	108 3	102 0	95 0	90 6	93 8
Pillowcase	95 8	100 7	93 8	94 4	94 1
Linen towel	114 2	107 2	100 5	94 6	95 4
Luncheon napkin	106 9	101 2	92 1	90 2	90 5
Man s shirt	106 6	99 2	99 7	95 9	93 7
Gauze diaper	101 7	97 0	89 0	88 8	90 8
Birdseye diaper	97 4	98 6	83 8	87 1	88 9
Rayon slip	101 3	96 3	93 2	90 5	91 3
Rayon blouse	109 0	97 6	98 8	92 2	93 1
Nylon slip	96 4	89 3	89 6	84 9	88 4
Knit T-shirt	100 3	98 8	94 9	91 0	96 1
Knit shorts	105 3	100 7	89 5	91 6	95 2
Linenized sock	106 0	99 6	93 0	93 1	91 5
Cotton sock	115 0	108 9	97 5	99 9	103 2

*All numbers over 100 indicate that the article was whiter than when new

When merely soaked and dried the rough surfaced articles such as gauze diapers, birdseye diapers, knit T-shirts, shorts, and cotton socks were slightly whiter when dried in the gas dryer than in the electric dryer or on the line.

The changes were so small from time to time by either method of drying that they were scarcely distinguishable to the eye and could be accurately measured only by the photo electric cell.

Color Retention. When colored items were dried out-of-doors the results were quite different than when dryer dried. Marked differences could be determined where sunshine had practically removed the red color. The same was true with rose towels and figured or striped materials in which red or any color containing a red pigment was used —pink and lavender. Blue dyes faded in sunshine but not as extensively as did the reds. (Table 5).

In the electrically heated dryer so little color change could be noted that, in most cases, they were hardly visible to the eye. Reflectance readings indicated that in some cases the colors were even brighter after 50 washings in hot detergent water and dryer dried than those measured on the new fabric. It is possible that, in these cases, the sizing in the new fabrics may have reduced the original reflectance.

In the gas heated dryer the blue dyes were adversely affected. In the case of terry cloth toweling the blue dye turned green. This same change was noted to a lesser degree in figured materials containing blue dyes. In order to check this characteristic a small follow-up study was made after the completion of this study.

Twelve plain blue and printed fabrics of varying materials and prices were purchased on the open market. Duplicate swatches of each material were soaked and dried 25 times at high, medium and low heat in the same dryer used in this study and in three other brands of dryers. Other swatches were air dried indoors because of weather conditions.

Those air and electrically dried showed no change in color evident to the eye. In the gas heated dryer some swatches changed color so greatly that they could not be recognized as being of the same color. Some turned a dirty, muddy green, others of varying shades had a greenish cast. Those dried at low heat for a longer period of time

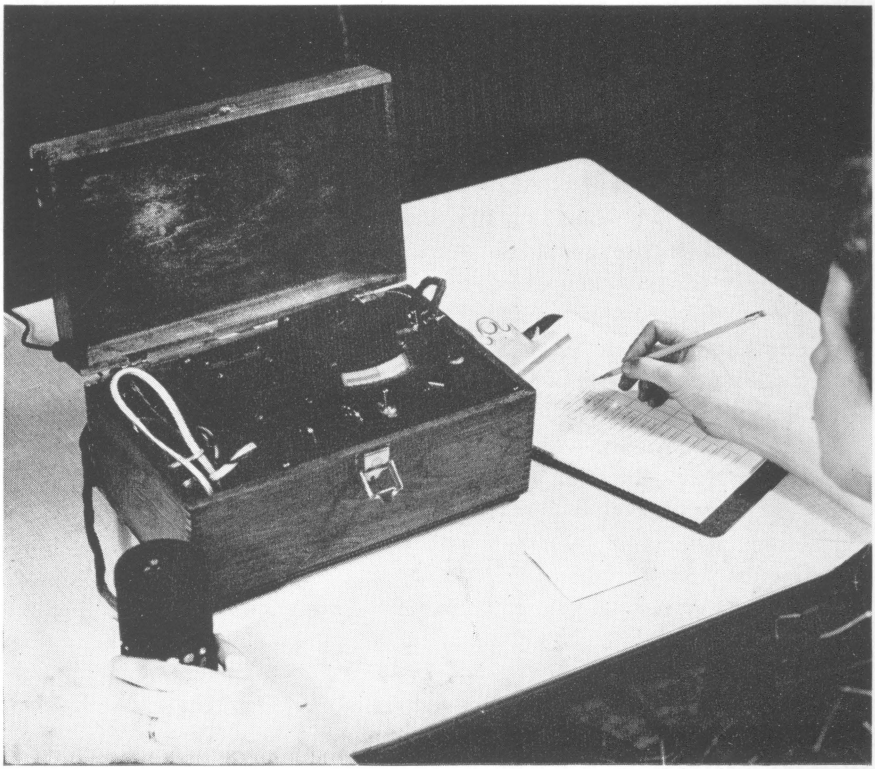

Fig. 9.—The photo-electric reflection meter used to determine whiteness and color retention of test items.

changed color to a greater extent than did those that were more quickly dried at high heat. While those blue dyes that tended to change color reacted in each of the dryers there were varying degrees of change in the different dryers. Some blue colors were not affected. Price of fabric was no factor.

Since some blues changed and others did not it was suspected that the type of dye might be a factor. Swatches of each fabric were sent to the American Association of Chemists and Colorists where the dyes have been analyzed. The members of the association have been alerted to the problem and consideration is being given to the composition of blue dyes that will not react chemically in the presence of gas.

SHRINKAGE AND DISTORTION TESTS

Purpose and Procedure

"Will the dryer shrink clothes more than line drying?" Women reported that they generally knew what to anticipate when line drying but frequently heard rumors of or experienced seemingly greater shrinkage in dryer drying.

Preparation of Materials and Testing Procedures

Fifteen of the 20 test items used for the shrinkage tests (Tables 6 and 7) were prepared according to directions of the American Society for Testing Materials.[7] One 10-inch square was marked with black mercerized cotton thread. Midpoint of each side of the square was marked with a running stitch to establish points for measuring (Fig. 10). After the first, 25th, and 50th tests, test materials were carefully dampened, pressed and measured with a steel ruler. Three measurements were taken on the warp and three on the filling directions. The average figure was used for calculation by the following formula:

$$\frac{\text{Original Length—Length after Washing}}{\text{Original Length}} \times 100 = \text{Percentage of Shrinkage}$$

Distortion of cotton knit items had been observed in previous studies. In other words, the items shrank in length but stretched in width. Since no method for determining distortion could be found in

[7]A.S.T.M. Standards on Textile Materials. American Society for Testing Materials, Philadelphia (1949), p. 363.

TABLE 5.—The Percentage of Color Retained by Articles after Washing or Soaking and Drying Fifty Times Out-of-doors or in Clothes Dryers

Article	Washed and Dried		Soaked and Dried		
	Out-of-doors	Electric dryer	Out-of-doors	Electric dryer	Gas dryer
			Percent*		
Child's sleeper	78.2	90.2	82.5	101.7	105.7
Flannel pajama	80.9	93.8	93.5	108.0	106.7
Blue towel	87.4	97.2	83.8	97.1	79.3
Rose towel	43.4	91.5	35.0	101.7	93.7
Luncheon napkin (border)	75.9	96.7	85.4	109.0	107.0
Seersucker (cotton)	16.2	98.6	14.3	69.0	97.0
Cotton print	76.7	96.8	92.0	105.2	103.4
Cotton pique					
Green	99.8	98.3	55.1	111.7	107.2
Blue	98.8	117.4	11.9	110.8	98.9
Purple	78.4	113.8	11.5	111.2	116.0
Pink	27.6	104.2	19.7	116.5	113.7
Yellow	81.4	94.2	89.9	107.5	105.1

*All numbers over 100 percent indicate a deepening of the color that was found in the article when new.

the literature the following method was devised. Landmarks were made with black cotton thread at structural points on the garments which were laid and charted on large graph paper. Different color pencils were used to chart the garments after 1, 15, 25, and 50 tests.

Results of the Tests

Shrinkage in practically every item, in both warp and filling directions was less when items were washed or soaked and line dried than when dryer dried. Likewise, washed item shrinkage by either drying method was greater than when clothes were merely soaked without agitation.

The greatest differences in the degree of shrinkage was in cotton knit T-shirts, 4.6 percent out-of-doors and 14.5 percent in the dryer (length). (Figs. 11 and 12). Shrinkage is inherent in cotton knits but was magnified in the dryer. To meet this problem one manufacturer of knit goods is at the present advertising that his products have been processed to resist dryer shrinkage. The process, known as "Perma-sized", is accomplished by both mechanical and chemical treatment.

TABLE 6.—The Percentage of Shrinkage Observed in Clothing and Household Articles after Being Washed and Dried One, Twenty-five and Fifty Times, Respectively

Article	Out-of-doors						Electric Dryer					
	Number of times dried						Number of times dried					
	Warp			Filling			Warp			Filling		
	1	25	50	1	25	50	1	25	50	1	25	50
Man's shirt	1.0	1.8	2.0	0.0	+ .2	+1.2	.4	3.6	4.2	+ .2	.3	.9
Crib sheet	5.2	7.9	8.2	3.3	4.2	3.6	3.5	8.8	9.4	3.2	4.3	4.6
Pillowcase	4.4	6.9	7.0	2.1	2.4	1.7	4.5	4.5	7.7	2.3	3.2	3.6
Gauze diaper	4.1	8.2	7.3	4.3	5.0	3.5	4.8	7.9	10.1	6.1	9.4	7.3
Birdseye diaper	7.2	11.9	10.8	2.5	3.0	1.6	9.5	14.7	16.9	4.7	5.6	5.6
Blue towel	3.7	4.5	5.0	+ .8	+1.8	+2.3	3.2	4.5	6.7	+1.6	+3.5	+ .4
Rose towel	3.6	4.6	5.2	+1.2	+1.6	+1.6	3.4	4.9	7.0	+1.7	+2.6	+ .3
Flannel pajama	2.4	6.1	6.4	+ .1	+2.3	+5.0	4.2	8.4	11.1	.5	+ .1	1.3
Rayon napkin	10.2	13.7	12.6	5.2	6.4	3.7	10.3	15.4	16.2	4.8	6.4	7.1
Rayon slip	3.1	8.0	3.9	2.5	2.9	2.6	4.2	11.4	13.7	1.5	2.2	2.4
Nylon slip	1.1	1.3	1.2	.8	.8	.5	1.4	1.4	2.3	1.0	.6	1.4
Cotton print	4.6	7.6	8.2	2.2	2.2	1.4	5.1	9.1	10.0	2.4	2.4	3.0
Linen towel	10.6	11.8	12.4	1.2	1.7	1.8	8.4	13.0	13.4	.2	2.4	3.7
Cotton pique	4.2	7.4	8.4	1.8	7.2	5.2	3.5	10.8	13.2	5.2	9.3	11.0
	Wales			Courses			Wales			Courses		
Knit T-shirt	2.1	4.5	4.6	+1.6	4.5	1.8	8.0	10.1	14.5	.4	+1.4	+2.8

*A plus sign indicates extension rather than shrinkage of the fabric.

TABLE 7.—The Percentage of Shrinkage Observed in Clothing and Household Articles after Being Soaked and Dried One, Twenty-five and Fifty Times, Respectively

Article	Out-of-doors						Electric dryer						Gas Dryer					
	Warp			Filling			Warp			Filling			Warp			Filling		
	Number of times dried						Number of times dried						Number of times dried					
	1	25	50	1	25	50	1	25	50	1	25	50	1	25	50	1	25	50
	Percent*						Percent*						Percent*					
Man's shirt	.7	.3	.8	.3	+ .3	+ .2	2.5	2.2	4.4	.4	.3	.4	2.6	4.6	5.8	.5	.6	1.6
Sheet	4.1	7.0	7.3	2.8	1.3	2.8	5.6	7.5	8.4	3.5	4.1	4.6	6.1	8.6	9.3	3.1	3.7	3.8
Pillowcase	4.3	4.8	5.5	2.8	2.1	2.6	4.3	6.4	6.9	2.6	2.8	3.2	4.2	6.4	7.0	2.9	3.1	2.7
Gauze diaper	4.6	5.8	5.7	4.0	5.2	5.1	3.4	6.7	8.8	5.5	6.4	9.8	4.6	8.8	8.3	6.7	9.3	9.5
Birdseye diaper	6.3	8.5	8.8	+5.5	1.6	3.1	8.5	14.4	16.1	4.4	5.9	7.3	8.6	15.0	16.0	5.0	7.0	7.5
Blue towel	3.0	3.7	3.6	+ .5	+1.0	+1.4	2.0	3.9	5.7	+2.2	+2.5	+1.6	1.9	3.9	4.5	+2.1	+2.5	+2.3
Rose towel	3.3	3.8	4.4	+ .5	+1.5	+1.4	†	5.0	5.8	+1.9	+1.3	+1.8	2.0	4.4	4.4	+2.3	+3.4	+2.1
Flannel pajama	3.0	4.0	5.2	2.8	1.4	.7	3.8	7.9	9.2	1.6	2.3	2.1	3.2	6.2	7.8	1.4	2.0	2.6
Luncheon napkin	9.4	9.1	12.0	+5.0	4.1	4.9	8.5	14.4	16.6	3.5	4.6	6.6	8.8	13.6	14.4	4.8	6.9	7.2
Rayon slip	3.2	2.5	2.7	2.4	.8	1.4	5.6	13.2	17.7	1.4	2.1	2.5	5.8	14.4	17.5	1.7	.9	2.8
Nylon slip	1.3	.7	1.5	.6	0.0	.6	1.4	1.4	2.8	1.4	+ .1	.6	.5	.7	1.1	0.0	0.0	+ .1
Cotton print	4.4	5.0	5.6	2.8	2.2	1.8	4.1	8.3	8.0	2.2	2.7	2.0	4.0	7.5	8.1	2.0	2.3	2.5
Linen tea towel	9.1	10.6	11.5	.7	.8	.9	6.9	10.8	11.7	0.0	1.1	1.6	7.1	11.6	14.0	0.0	.4	2.7
Cotton pique	3.5	3.7	3.8	1.3	2.0	3.1	1.6	9.0	10.3	4.0	8.7	9.9	1.8	8.0	9.7	3.8	7.5	9.4
	Wales			Courses			Wales			Courses			Wales			Courses		
Knit T-shirt	2.9	2.9	4.6	0.0	+1.6	2.4	7.0	12.2	12.7	+ .1	.6	.3	7.1	12.9	11.7	+ .1	+1.7	.7

*A plus sign indicates extension rather than shrinkage of the fabric.

†By error measurement was not recorded.

Sanforized, preshrunk, broadcloth in men's shirts shrank 4.2 percent after 50 washings and drying in the dryer, which was beyond the specific 1 percent residual shrinkage guaranteed by the process.

Terry cloth towels, by nature of their weave, extended in length in each method of drying.

Shrinkage in the first drying by either method was comparable but dryer dried items showed greater progressive shrinkage up to the 25th drying with a lesser percentage of increase between the 25th and 50th drying.

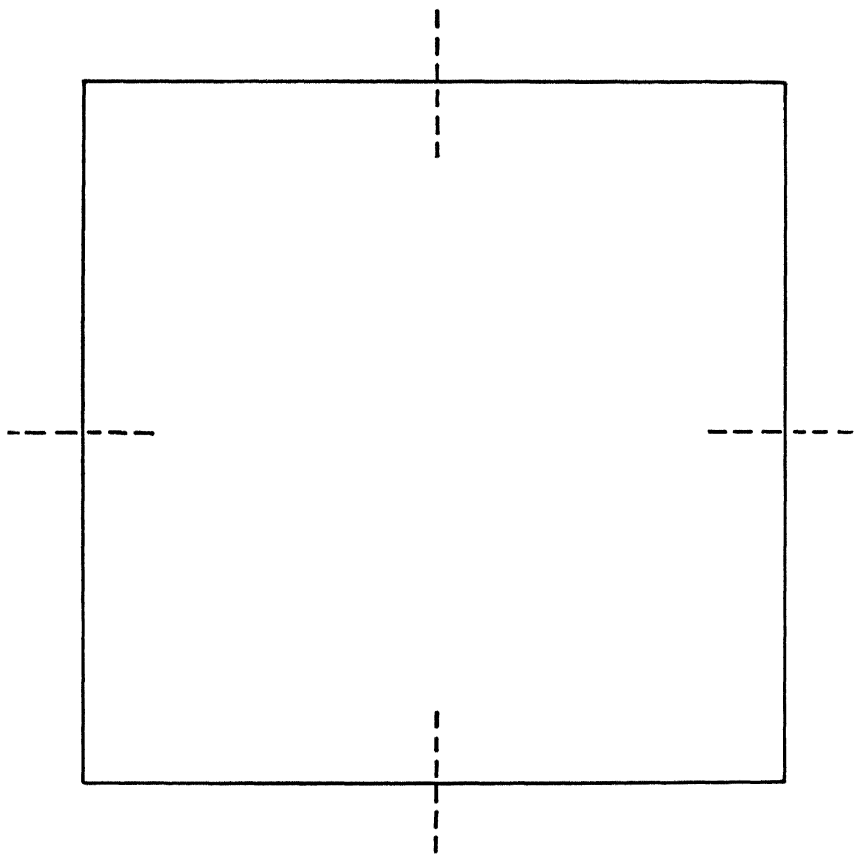

Fig. 10.—Diagram showing the method of marking swatches for measuring shrinkage.

Scale: 1 inch equals 2 inches
——— black thread - - - - - running stitch

There seemed to be no appreciable difference in the degree of shrinkage in the electrically or gas heated dryer. In some items the shrinkage was slightly greater in the gas heated model while with other items the shrinkage was slightly more in the electric model.

The drying of woolens was not a part of this study but results of a previous study on the laundering of blankets are relevent to the problem of shrinkage.

Experimentation with all-wool blankets proved that they could be satisfactorily dried in a dryer if careful manipulation is employed. In this drying process the dryer should be preheated for at least 5 minutes at highest heat setting. To buffer the mechanical action, 5 or 6 large dry bath towels should be preheated. When the washed, wet blanket is added the towels should be mixed into the folds. A drying time of approximately 15 minutes at high heat is generally sufficient to remove about 75 percent of the water from a 3 pound (dry weight) blanket. Heavier weights may require a slightly longer time. The blanket should be removed while slightly damp (never allow a wool blanket to dry completely). Follow by stretching and blocking, and brushing with a stiff nylon hair brush or a pet brush (steel bristles set in rubber) to raise the nap of the blanket. For complete techniques write for "The Laundering of Blankets in Automatic Washers and Dryers", Bulletin 717, Ohio Agricultural Experiment Station, Wooster, Ohio.

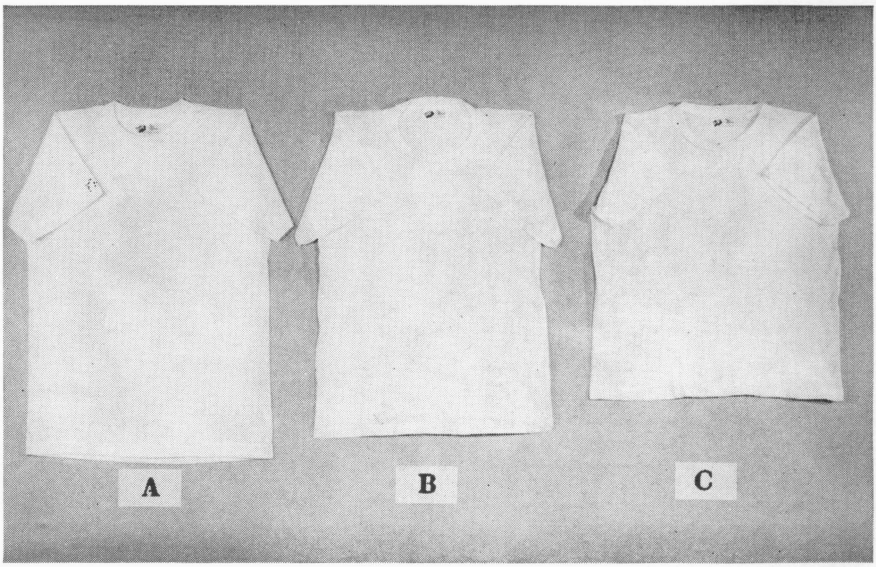

Fig. 11.—Shrinkage and distortion of cotton T-shirts.

A. New
B. After 50 washings and dryings out-of-doors
C. After 50 washings and dryings in the electrically heated dryer

While no means were devised to calculate the degree of distortion or change in shape of the knit items (the chart in figure 12) it was found that T-shirts and other cotton knits (non-test pieces) could be quite satisfactorily stretched back into shape and length if removed from the dryer while slightly damp and elastic. Further work done by some manufacturers' home economists indicates that there is a lesser degree of shrinkage in these fabrics when they are dried at low and medium temperatures (approximately 150°-170° F. maximum) rather than at high heat (190° F.) and removed while still slightly damp.

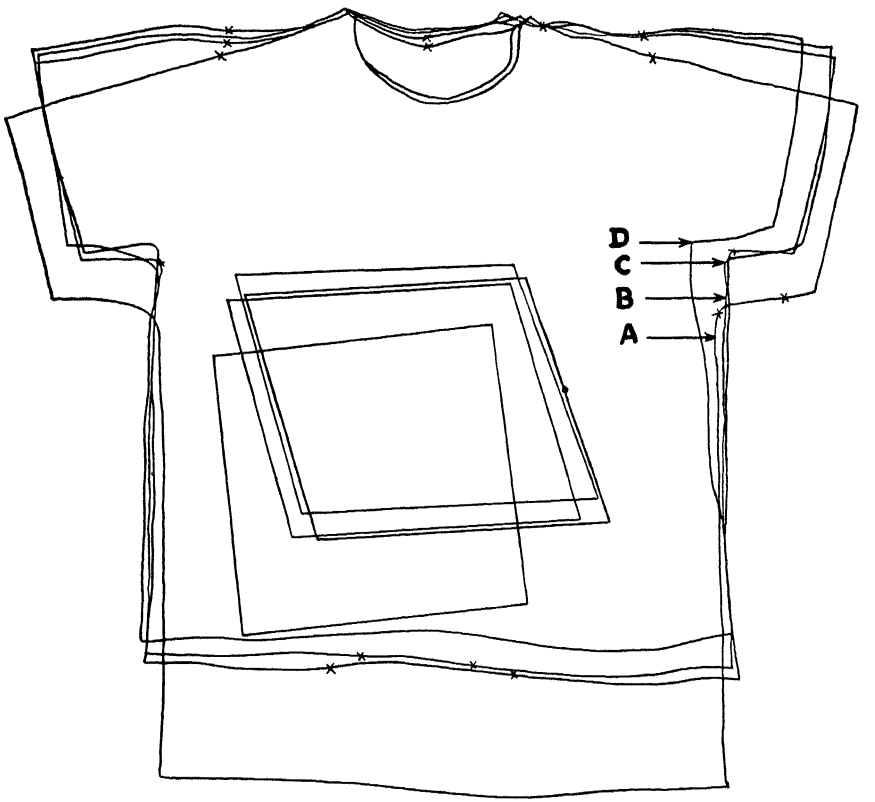

Fig. 12.—Chart showing a man's new cotton knit T-shirt and the shrinkage and distortion following the fifteenth, twenty-fifth, and fiftieth tests in which it was washed and dried in an electrically heated dryer.

A. Before washing and drying
B. After 15 tests
C. After 25 tests
D. After 50 tests

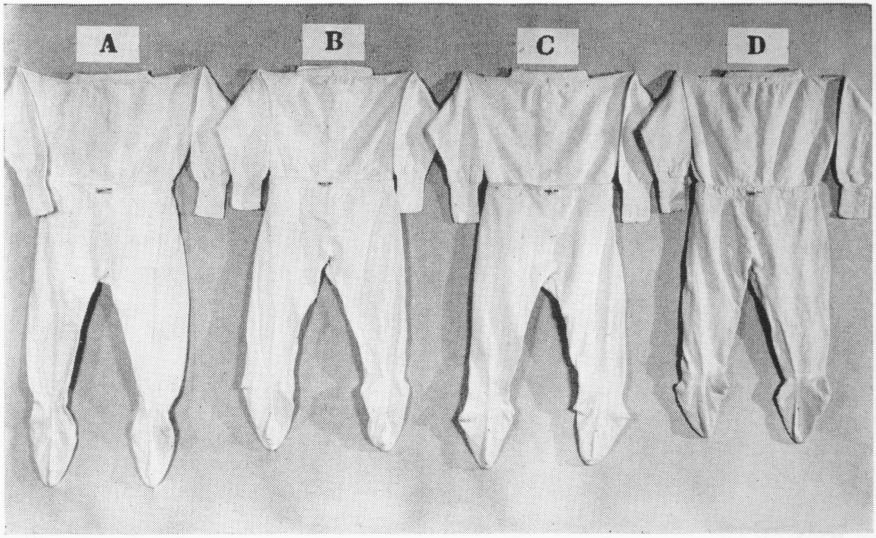

Fig. 13.—Shrinkage observed in children's cotton knit sleepers.

A. Soaked, line dried
B. Soaked, dried in electrically heated dryer
C. Washed, line dried
D. Washed, dried in electrically heated dryer

Over-drying, that is, drying for a period of time after all moisture is removed is believed to contribute to increased shrinkage and distortion. Tests on this factor were not attempted in this study.

Although shrinkage and distortion were somewhat greater in dryer than in line drying most items were softer and more resilient and, in the case of diapers, more absorbent when dried in the dryer. In the selection of cotton knit items to be dryer dried it would be advisable to choose a size larger than needed unless they have been treated to resist shrinkage.

WEATHER CONDITIONS DURING STUDY

Independence from weather conditions has been the strongest selling point for the manufacturers of dryers.

Weather records of Columbus, Ohio, for 40 years showed an average per year of 120 days with measurable precipitation, 107 days with partly cloudy skies, and 134 clear days.[8]

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[8]**Climate and Man** United States Department of Agriculture, (1941)., pp. 1063-64.

During the 5 month period (151 days) February through June, 1951, while the drying tests were being conducted, there were 92 days (60.9 percent) in which precipitation (rain, snow, or sleet) occurred. The temperature on 40 percent of the days was 32° F. or below; strong winds of more than 20 miles per hour prevailed on 67 days. On 25 other days there was no sunshine. During the period, only 34 days, 23 percent, could be considered "good" drying days.

Dryer drying was done at any hour of the day without concern of weather conditions.

COST OF OPERATION OF DRYERS

"How much will it cost to operate a dryer?" During the drying of 50 test loads in the electrically heated dryer (44 minutes per load) an average of 2.7 kilowatt hours of electricity was consumed. The cost to the individual would depend upon the total consumption of current in the home. At the rate of 2.5¢ per kilowatt hour the cost would be 6.7¢ per load. If an average of 4 loads were dried weekly the cost would be 26.8¢ or $1.08 per month.

Approximately 9.6 cu. ft. of gas was consumed per load in the gas heated dryer. At the Columbus gas rate of 1¢ per 20 cu. ft., sixteen loads a month (153.6 cu. ft.) would cost 7.7¢. (Plus approximately 7¢ per month for electricity for operation of the electric motor).

While the cost of operation of an electrically heated dryer is somewhat more expensive it should be kept in mind that the initial cost is from $25.00 to $45.00 less than that of a gas heated model of the same brand.

FURTHER OBSERVATIONS

TIME REQUIREMENT FOR HANGING CLOTHES OUT-OF-DOORS AS COMPARED TO LOADING THE DRYER

"How much time can an automatic dryer save for me?" was a question frequently asked. Micromotion films were taken and analyzed of one trip to and from the line and the hanging of clothes. Time and number of steps were recorded for 15 each of out-of-door and dryer dried loads of 8 pounds of clothes.

Line drying required 625 steps and 57.5 minutes from the washer to hang clothes, later remove and fold them from the line, and return to the laundering area. Dryer drying required only three steps and 9 minutes in the process of loading the dryer from the washer, removing

and folding all items; in other words, less than 1/6 of the time was required for the operations of the worker. Walking was almost completely eliminated as were stooping, bending, reaching and lifting.

Further analysis for complete comparison of energy requirements would be of value.

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